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Based on a construct termed "sensitivity" of the nervous system and the assumption that field-dependence is an indirect approximation of level of "sensitivity," our previous research has predicted and found field-independent groups to be superior to field-dependent groups in color and weight discrimination and in contrast sensitivity. Here, we re-examine weight judgment using a more discriminating test and attempt to replicate previous color results. Seventeen females performed a weight discrimination task (15 weights, 75-145 grams, in 5-gram increments) on two successive days, three trials/day, and two trials on the Farnsworth-Munsell 100 Hue Test. A field-independent group (N=5) performed significantly better than a field-dependent group (N=6) on all trials of both tasks. Although N is small, this is the fifth replication (in five attempts) of the color discrimination results and a strong validation of the previous results with weights. It is suggested that in studies of sensory discrimination, some of the so-called "random error" now must be considered as systematic error, or bias, and that attention should be given to level of "sensitivity" of participants.

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Attach this memo to DF

This article, in a somewhat different form has already been cleared by CO, USARIEM for publication (Clearance No. M66-88).

Originally, it was part of a larger, more complex article entitled: "Field-dependence, judgment of weights by females and an appeal for a more complex approach to the study of individual differences," submitted to Personality and Individual Differences.

The editor indicated that the combining of what were essentially two articles made him "uneasy" and suggested separating the two and re-submitting the more empirical one.

I have separated the two, but have decided to send them to different journals...more appropriate journals, the editors of which have no vested interest inthe subject matters, as was not the case in the previous submission where Dr. Eysenck has trouble accepting views other than his own.

The second, more theoretical piece also will be re-written and will be re-submitted soon.

Field-Dependence and Judgment of Weight and Color Revisited:

Some Implications for the Study of Sensory Discrimination

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Abstract

Based on a construct termed "sensitivity" of the nervous system and the assumption that field-dependence is an indirect approximation of level of "sensitivity," our previous research has predicted and found field-independent groups to be superior to field-dependent groups in color and weight discrimination and in contrast sensitivity. Here, we re-examine weight judgment using a more discriminating test and attempt to replicate previous color results. Seventeen females performed a weight discrimination task (15 weights, 75-145 grams, in 5-gram increments) on two successive days, three trials/day, and two trials on the Farnsworth-Munsell 100 Hue Test. A field-independent group (N=5) performed significantly better than a field-dependent group (N=6) on all trials of both tasks. Although N is small, this is the fifth replication (in five attempts) of the color discrimination results and a strong validation of the previous results with weights. It is suggested that in studies of sensory discrimination, some of the so-called "random error" now must be considered as systematic error, or bias, and that attention should be given to level of "sensitivity" of participants.

Field-Dependence and Judgment of Weight and Color Revisited: Some Implications for the Study of Sensory Discrimination

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In this paper, previous theoretical considerations and research results are reviewed and new data are presented, all of which suggest that in psychophysical experiments involving sensory discrimination, the source of some of the "between-person" variance, sometimes referred to as "noise" or "random error", can be identified systematically.

Fine (1972) has presented evidence of a strong, non-linear relationship between field-dependence-independence (hereinafter referred to as "field-dependence;" Witkin, 1964, 1965; Witkin, Dyk, Faterson, Goodenough & Karp, 1962), introversion-extraversion (hereinafter referred to as "extraversion;" Eysenck, 1967) and neuroticism (Eysenck, 1967). In the context of that relationship, he suggested that differences between individuals in field-dependence might be conceptualized profitably as at least <u>partially</u> genetically-based differences in "sensitivity," as contrasted with "strength" (Eysenck, 1967), of the nervous system.

Differences in "sensitivity" were conceived as being dependent upon the extent to which the nervous system becomes "differentiated" as an individual develops; the greater the extent of "differentiation," the greater the "sensitivity." "Differentiation" differed from its use by Witkin et al. (1962) in that it was considered in its biological (rather than socio-psychological) sense to be ultimately referable to <u>physical</u>

characteristics of components of the nervous system or of the nervous system as a whole, e.g., size, number and/or distribution of specific types of receptors, elaborateness or complexity of neural networks, quality or quantity of neural transmitter substances, with these ultimately reducible to differences in underlying substrates, e.g., enzymes and proteins (Fine, 1972, 1973). Recent progress in several areas of research appears to lend some credence to these speculations about the bases of individual differences, e.g. Curcio, Sloan, Packer, Hendrickson & Kalina, 1987; Haier (cited in Hostetler, 1988) and Livingstone & Hubel, 1988.

From this conceptual base, it was reasoned that "sensitivity" of the nervous system should be related to ability to discriminate among stimuli, the more differentiated and, hence, the more "sensitive" the system, the better the ability to discriminate. Because of his specific interest in field-dependence at the time, Fine postulated that individuals with highly "sensitive" nervous systems should be those who are <u>most</u> proficient on spatial perception tests such as the Hidden Figures Test (HFT; Witkin, et al. 1962) or the Gottschaldt Hidden Shapes Test (HST; Cattell, et al., 1955) from which the HFT was derived, i.e., individuals who, in Witkin's schema, had come to be called "field-independent." Conversely, individuals with relatively "insensitive" nervous systems were postulated as being those who are <u>least</u> proficient on tests of spatial perception, and who had come to be referred to as "field-dependent." Thus, Witkin's concept, <u>field-dependence</u>, became a construct which was thought to be at once a behavioral manifestation of and <u>an indirect approximation of</u> the level of development of aspects of the nervous system.

To test the generality of the "sensitivity" hypothesis, a number of studies of the relationship between field-dependence and other types of complex sensory discrimination have been carried out. To date, the hypothesis has been tested and very strongly supported with respect to both the discrimination of colors (Fine, 1973) and contrast sensitivity (Fine & Kobrick, 1987), and, to a lesser extent, with discrimination of weights (Fine, 1973). The color discrimination results now have been replicated a number of times with male subjects [Fine & Kobrick, 1980, 1983 (color test given, but results not reported), 1987 (p.781)] and also in a study specifically focussed on females (Fine, 1983a). In <u>all</u> of the studies of the discrimination of colors and in the contrast sensitivity study, the performance of field-independent groups was markedly superior to that of field-dependent groups. The weight discrimination data showed the same general tendency, but not as unequivocally. The results of the five color discrimination studies are summarized in Table 1.

Insert Table 1 About Here

Two major shortcomings of the weight discrimination study (Fine, 1973) were that the test used to measure weight discrimination ability was too difficult (differences between stimuli were on the order of four grams) and too attenuated (only eight weights were judged, against two anchor points.) There also was an indication that weight discrimination was related to extraversion as well as to field-dependence. No relationship with extraversion had been found in any of the color discrimination studies or in the contrast sensitivity study.

Accordingly, the research presented here was designed specifically to re-examine the relationship between field-dependence and the ability

to judge weights, using a different weight discrimination test, and to inquire further into a possible relationship between extraversion and discrimination of weight.

To further verify the relationship between field-dependence and the discrimination of colors, a color discrimination test also was given.

Consistent with the "sensitivity" hypothesis, it was predicted that a group of field-independent persons would perform significantly better than a group of field-dependent persons on both the weight and color discrimination tasks. No predictions were made regarding a possible relationship between extraversion and weight discrimination.

Method

Subjects

Subjects (Ss) were 17 female soldier volunteers, ages 20-34 (median=22) who had been screened by a physician to insure that they were in good health for participation in a larger study of which this one was a part (Fine, 1987). Written informed consent was obtained from each S.

Measures

(a) Field-dependence was assessed by the HST (Cattell, et al., 1955). Participants were categorized on the basis of norms established from test scores of 154 female soldiers previously tested with the HST. Persons with scores in the lower third of that distribution (18 or below; N=6) were classified as field-dependent, those scoring in the upper third (26 or higher; N=5) as field-independent and the remainder (N=6) as "field-central" (norms based on 600 males are slightly different; cutoff points are one point higher in each category).

(b) Extraversion was measured with the Maudsley Personality

Inventory (MPI; Eysenck, 1959) rather than with later inventories by the Eysencks, since norms from a large soldier population (N=600+) were available for the MPI from our past research. Ss were divided into three groups based on those norms (male and female norms were identical). Persons scoring in the lower third of the distribution (26 or below; N=3) were classified as introverts, those in the upper third (34 and higher; N=9) as extraverts, and the remainder of the group (N=5) constituted a "middle" category.

(c) The weight discrimination task consisted of 15 white plastic cylinders, each 3.4 cm. in diameter and topped with a black plastic cap, 4 cm. in diameter. Cylinders with caps were 5.3 cm. tall. They were filled with tiny metal bearings to specific weights. Empty space in each cylinder was filled with cotton. The weight of the cylinders ranged from 75 to 145 grams in 5 gram increments +/- .1 gram. (Pre-tests had indicated that within the 75-150 gram weight range, five grams was discriminable approximately 50% of the time by about 50% of the respondents.) Each cylinder was numbered on the bottom with its appropriate rank, in increasing order of heaviness, from 1 to 15.

Cylinders were thoroughly shuffled and S was instructed to use her preferred hand to arrange the cylinders from lightest to heaviest using any method of comparison she desired. Ss were monitored carefully to insure that they did not invert the cylinders. After each trial, the ordered cylinders were turned over and the order of arrangement was recorded. Ss were allowed to see how well they had done. During the ensuing rest period, cylinders were returned to the starting position and reshuffled for the next trial.

(d) Color discrimination ability was measured by the

Farnsworth-Munsell 100-Hue Test (Farnsworth, 1957), which was designed to separate persons with normal color vision into classes of superior, average and low color discrimination ability and to measure zones of color confusion of color defective persons. The test has four sets of colored discs mounted in small plastic caps (3 sets of 21 and 1 set of 22 caps). Each set, contained in its own case, represents a different series of ostensibly just noticeably different shades of colors, e.g., from green to blue, when the caps are arranged in proper order. Two caps are attached permanently to each case, one at each end, and serve as judgmental anchor points.

Each set of caps was arranged in the same predetermined random order for all Ss. The Ss' task was to rearrange the caps into the appropriate sequence of colors between each pair of anchor points. The caps were numbered on the undersides to facilitate scoring. The numbers were not visible to the Ss.

The test was administered to each S in the same order (Series I, Caps 22-42; Series II, Caps 43-63; Series III, Caps 64-84, and Series IV, Caps 85-21). The order of administration was different from that stated in the test manual, consistent with the recommendation of Taylor (1976) that red-green defectives not be exposed to their areas of weakness on the first administration.

All Ss wore disposable plastic gloves while performing in order to prevent soiling of the colored discs.

Design and procedure

Each S was tested with the weight test at the same time in the afternoon on two successive days, three trials per day. A five-minute time limit was allowed for each trial. Inter-trial intervals also were

of five minutes duration to allow for recovery from fatigue induced by the demanding task. Ambient temperature and humidity conditions were controlled, normal (21.1°C., 50%RH) and constant for all Ss.

The color discrimination test was taken the afternoon prior to the first administration of the weight discrimination test. Two trials were given, separated by a five-minute interval. Ss were encouraged to complete each series within two minutes, but were allowed to finish if the time limit was exceeded. All times were recorded and very few Ss exceeded the time limit. No relationship was found between elapsed time and quality of performance. The task was performed in a climatically controlled (21.1°C., 50%RH), darkened, quiet room. Sole illumination was by a 100-watt tungsten filament source through a Corning Roundel filter mounted on a Macbeth ADE-10 easel lamp, placed directly above the work area, as recommended in the manual for the test (Farnsworth, 1957).

Persons who administered the color test had no idea of Ss' levels of performance on the weight test. Persons who administered either the weight or color test were unaware of Ss' scores on the tests for field-dependence or extraversion.

Results

Both the weight and color discrimination tests were scored with the system used for the color test (Farnsworth, 1957). The score for a given weight cylinder or color disc was the sum of the difference between the initially assigned number of that cylinder/disc and the numbers of the cylinders/discs immediately above and below it in the ordering that had been established by the S. Thus, correct placement of all cylinders/discs in the series resulted in each cylinder/disc receiving a score of 2. Incorrect placement of cylinders/discs resulted in

individual cylinder/disc scores in excess of 2, herein termed "error scores." For example, a two-cylinder/disc transposition (...4,5,7,6,8,9...) resulted in an error score of 4; a three-cylinder/disc transposition (...4,5,7,8,6,9,10...) resulted in an error score of 8, etc.

One-tailed t-tests were used to test the predicted differences between field-independent and field-dependent groups in weight and color judgment for each trial and for combined trials.

The mean error scores for the weight discrimination task for each field-dependence sub-group, by trials, day and combined days, are shown in Table 2, along with the respective t-tests and p-values for the field-dependence/field-independence group comparisons.

Insert Table 2 About Here

The differences in error scores between field-independent and field-dependent groups are very large and all comparisons are statistically significant.

The mean error scores for the color discrimination task, for each field-dependence sub-group, by trials and combined trials, are shown in Table 3, along with the respective t-tests and p-values for the field-dependence/field-independence group comparisons. All comparisons are statistically significant.

Insert Table 3 About Here

No significant effects were found for extraversion, either with the weight judgment or the color discrimination task. The correlation between field-dependence and extraversion was not significant (r=.06), consistent with most of the literature (Fine, 1983b).

Discussion

The results clearly support the prediction that a field-independent group would be superior to a field-dependent group in weight discrimination performance. Taking the average for the six trials, which, perhaps, is the best indicator of differences between groups, the $t=3.38$ yields a W^2 (Hays, 1963) of .49, indicating that field-dependence accounted for nearly 50% of the variance in weight discrimination performance.

The color discrimination results support the prediction for the sixth time in six attempts at validation, using different Ss and different technicians in each replication.

In summary, in a series of studies in which we used a construct referred to as "sensitivity" of the nervous system (based on the biological concept of "differentiation" of the nervous system), and an assumption that field-dependence is an indirect approximation of <u>level</u> of "sensitivity," we successfully have predicted differences between identifiable groups of people in the accuracy of their judgments within three very different sensory modalities; color discrimination (with five replications including the present study), weight discrimination (replicated here) and contrast sensitivity. We expect that similar systematic differences in judgment may occur with respect to other sensory domains.

It follows from the above that an experiment which involves sensory judgments and in which the subject population is made up predominately of field-dependent persons, will yield different results from an experiment in which field-independent persons predominate, whether by

intent or by chance. This, then, changes to systematic error, or bias, some of that which previously has been referred to as "random" error.

Once informed of this, one should have difficulty accepting the generalizability of results about sensory judgments from any study in which the (now) relevant characteristics (field-dependence) of the subject population have not been considered and specified.

It should be noted that despite the clear-cut statistical significance of our data, there are individuals who do not conform to the predictions. They will be the focus of further theoretical and empirical efforts.

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Table 1

Color Discrimination Error Scores: Farnsworth-Munsell 100 Hue Test*

Summary of Comparative Performance of Field-Independent

and Field-Dependent Groups over Five Studies

Study	Independent N	Independent Mean Total Trial One	Dependent N	Dependent Mean Total Trial One	t	P (1-tail)
Fine, 1973	27	46.4	24	111.9	4.38	<.001
Fine & Kobrick, 1980	11	59.3	15	125.6	2.56	<.009
Fine & Kobrick, 1983	4	44.0	14	123.1	2.08	<.03
Fine, 1983a	8	24.3	8	102.0	4.34	<.001
Fine & Kobrick, 1987	8	61.6	12	103.0	1.40	<.09

* Lower score= better performance

Table 2

Mean Error Scores for Weight Discrimination Task

for Field-Dependence Sub-Groups by Trials and Days

		Day 1				Day 2				Days 1+2
		Trials								
Group	N	1	2	3	1-3	4	5	6	4-6	1-6
Field-Dependent	6	29.8	22.0	22.5	24.8	19.5	18.3	20.2	19.2	22.0
Field-Central	6	18.2	20.3	12.7	17.1	17.7	13.5	11.0	14.1	15.5
Field-Independent	5	14.4	7.2	12.4	11.4	9.8	10.8	14.0	11.5	11.5
t-test; Dep.vs.Indep.		2.19	3.05	1.82	3.21	2.13	1.47	1.34	2.26	3.38
P (1-tail)		.03	.007	.05	.005	.03	.09	.11	.03	.004

Table 3

Mean Error Scores for Color Discrimination Task

For Field-Dependence Sub-Groups by Trials

		Trials		
Group	N	1	2	1 & 2
Field-Dependent	6	81.2	71.8	76.5
Field-Central	6	86.8	77.2	81.5
Field-Independent	5	33.6	35.8	34.7
t-test: dep.vs. indep.		1.85	1.99	1.95
P (one-tail)		<.05	<.04	.04

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This research conformed to US Army Research and Development Command Regulation 70-25 on Use of Volunteers in Research. I would like to thank Ms. Edith A. Crohn and SP4 Linda S. Gowenlock for their assistance in administering the color and weight discrimination tests. Correspondence and requests for reprints should be sent to Bernard J. Fine, U.S. Army Research Institute of Environmental Medicine, Army R.D. & E. Center, Natick, MA 01760.